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MAGNETISM

Magnetic State of Quasiordered Fe–Al Alloys Doped with Ga and B: Magnetic Phase Separation and Spin Order

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Abstract—Results of structural, magnetic, and Mössbauer studies of quasi ordered alloys $Fe_{65}Al_{35-x}M_x$ (M_x = Ga, B; x = 0, 5 at %) are presented. The magnetic state of examined structurally –single-phase alloys at low temperatures is interpreted from the viewpoint of magnetic phase separation. An explanation is proposed for the observed behavior of magnetic characteristics of $Fe_{65}Al_{35}$ and $Fe_{65}Al_{30}Ga_5$ in the framework of the model of two magnetic phases, a ferromagnetic-type one and a spin density wave. The boron-doped alloy $Fe_{65}Al_{30}B_5$ is shown to demonstrate behavior that is typical of materials with the ferromagnetic type of ordering.

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INTRODUCTION

Long-period collinear and noncollinear random [1] and ordered [2–4] structures of magnetic moments remain one of the most intriguing subjects in contemporary solid-state physics. Apart from the need to understand the reason for their existence [2], they are closely related to superconductivity [2–4] and are topical in spintronics [5]. Notions about the nature of nanoscale magnetic structures differ. It is contemplated that they may occur due to competing exchange interactions, Fermi surface nesting, and low-lying thermal excitations. Moreover, the very identification of such structures remains a difficult challenge. Correlation of magnetic moments with a coherence length of approximately 5 nm was discovered [6] in neutron diffraction studies of *B*2-type ordered Fe–Al alloys. The observed ordering of magnetic moments was explained from the viewpoint of spin density waves (SDWs). It was revealed that the spin density wave has the greatest coherence length in quasiordered $Fe_{100-x}Al_x$ alloys for the concentration x = 35 at %. Elsukova et al. [7] studied the magnetic transport properties of quasiordered alloys $Fe_{100-x}Al_x$, x = 30–35 at % and explained abnormal behavior of the magnetoresistance and Hall constant based on the model of an nonuniform magnetic structure.

Quasiordered Fe–Al alloys with an Al content of 25–40 at % are of interest in this context as model objects for researching the nature of occurrence and stabilization of magnetic inhomogeneities in structurally uniform magnets, in particular, incommensurate long-period spin structures. It is believed that small additions of a third element, for example, Ga or B, to $Fe_{65}Al_{35}$ alloy will make it possible to trace changes in the magnetic state of the original alloy and thereby clear up the peculiarities of its magnetic microstructure.

The goal of this work is to study the magnetic state of ternary quasiordered alloys $Fe_{65}Al_{35-x}M_x$ (M_x = Ga, B; x = 5 at %) based on analyzing the data of structural, Mössbauer, and magnetometric measurements and comparing these data to the results of similar research for $Fe_{65}Al_{35}$ alloy.

1. EXPERIMENTAL

Binary and ternary quasiordered alloys $Fe_{65}Al_{35}$, $Fe_{65}Al_{35-x}M_x$ (M_x = Ga, B; x = 5 at %) were prepared by thermal treatment of random nanocrystalline alloys synthesized by mechanochemistry. The alloys were synthesized in a FRITSCH P-7 planetary ball mill, equipped with ShKh-15–hardened-steel vessels and balls, in Ar atmosphere for 16 h from original powders